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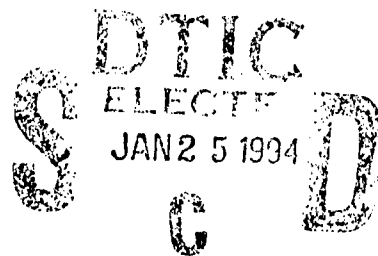


MULTICHIP MODULE  
HIGH SPEED TESTING

ARPA/ONR  
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Quarterly Progress Report  
October 1, 1993-December 31, 1993

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Progress for the period October 1, 1993 - December 31, 1993 is described below, in the areas of the electrooptic testing of multichip modules.

***a-Si:H Photodetector Fabricated on an Optical Fiber***

Last quarter, we reported Al/SiO<sub>2</sub>/Al capacitor structures formed on an optical fiber, as the first step toward an electrooptic test probe. We have now fabricated an amorphous hydrogenated silicon (a-Si:H) photodetector directly on an optical fiber. A 1  $\mu\text{m}$  film of (nominally undoped) a-Si:H was deposited at 300° C by plasma-enhanced chemical vapor deposition (PE-CVD) using silane and nitrous oxide. The deposition was made onto a glass slide on which optical fiber sections, stripped of their outer polymer jackets using methylene chloride, were held down using cured polyimide. Probe contacts were then made to the a-Si:H film to form a simple photoconductor with a  $\sim 1000 \mu\text{m}$  gap, which was then tested at 5-10 V bias under mechanically chopped illumination conditions (1 kHz, 633 nm, approximately 0.14 W/cm<sup>2</sup>). We estimate a conservative lower bound to the contrast ratio (ratio of conductivities under illuminated and dark conditions) of 10<sup>2</sup> under these conditions; see Figure 1. A figure of at least 10<sup>3</sup> is more probable, inferred from the character of material deposited on the planar substrate. The measurement of the dark conductivity was complicated by pick-up noise due to the probes.

We are presently improving our ohmic contacts to the a-Si:H film. Future problems to be solved include the coupling of travelling modes in the fiber to the detector, using either D-shaped or etched fiber geometries; the lithography of a smaller gap size, made complicated by these highly non-planar microfabrication conditions; and optimization of the speed response of the detectors as a function of geometry and doping.

***Electrooptic Testing using Electrooptically Active Polymers***

We have been investigating the use of electrooptically active polymers for the purpose of electrooptic testing. Important problems remaining to be solved are low electrooptic efficiency and geometry; detection system speed, efficiency, and noise; and optical alignment.

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While earlier experiments have used polymers in transmission-type experiments, most MCM electrooptic testing will undoubtedly utilize reflection-type geometries. For reflection mode operation a new sample was prepared (see Fig. 2). The copolymer (PMMA:MA1) was spun and baked dry onto an ITO coated substrate giving a film thickness of approximately 2 microns. A clear photopolymer was then spun on and cured on top of the PMMA:MA1; the latter prevented electrical breakdown, allowing the use of higher electrical fields during poling. The total polymer thickness was approximately 4 microns. An Al electrode was evaporated onto the polymer to serve as both a poling electrode (ground plane) and reflective back surface. The material was then poled at 132° C, the glass transition temperature, with 450 V across the 4 micron electrode gap, corresponding to 1.125 MV/cm.

The sample was then illuminated with 8 mW of 632 nm light from a HeNe laser. While previous experiments have utilized a 780 nm diode laser, the ease of alignment of the visible beam offset the disadvantage from the slightly reduced electrooptic response (approximately 9%) of the polymer at the shorter wavelength. Besides the simple increase in the signal-to-noise ratio (SNR) that due to this geometry and improved polymer response, the higher signals allow us to use a single photodiode detection scheme rather than the dual-detector subtraction arrangement which was previously needed to reduce noise. The higher capacitance of the latter had complicated higher speed measurements (mostly due to amplifier-diode oscillation), even when the diode capacitances were reduced using reverse bias. In the case of repetitive signals, SNR could be improved by averaging numbers of waveforms using the oscilloscope (Tektronix TDS 520).

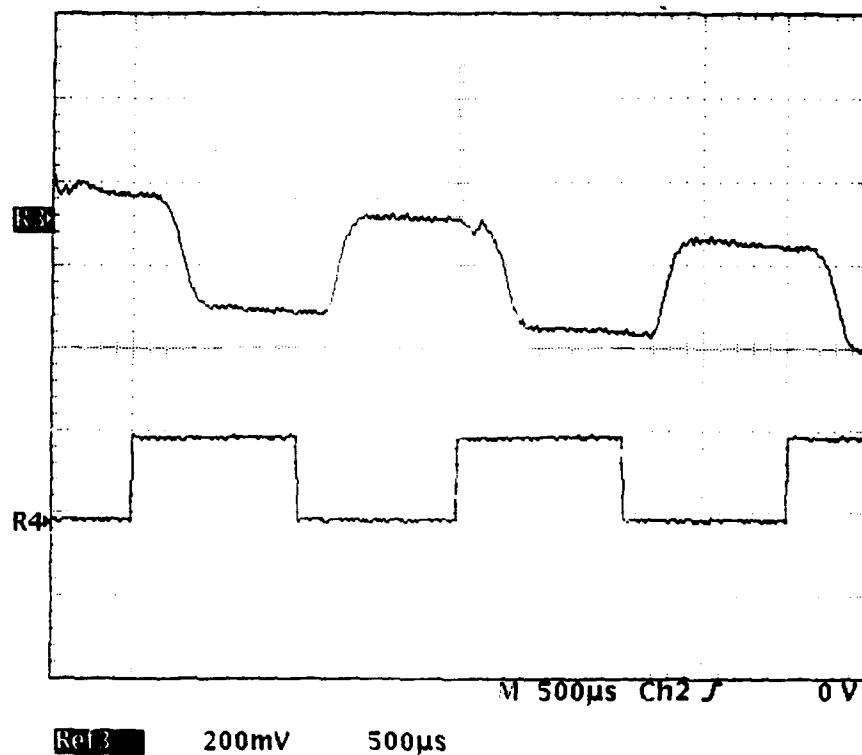
Figure 3 shows traces obtained at 100 kHz with an amplified single photodetector (New Focus 1601) of gain 250 V/A, both single waveform and an average of 30 waveforms. We have also observed signals of adequate SNR (~ 15 dB) at 1.0 MHz utilizing averages of five waveforms with a single unamplified detector (Thorlabs). Future experiments will utilize high-speed single photodetectors with bandwidths of up to 1 GHz with higher gains.

### ***Intellectual Property***

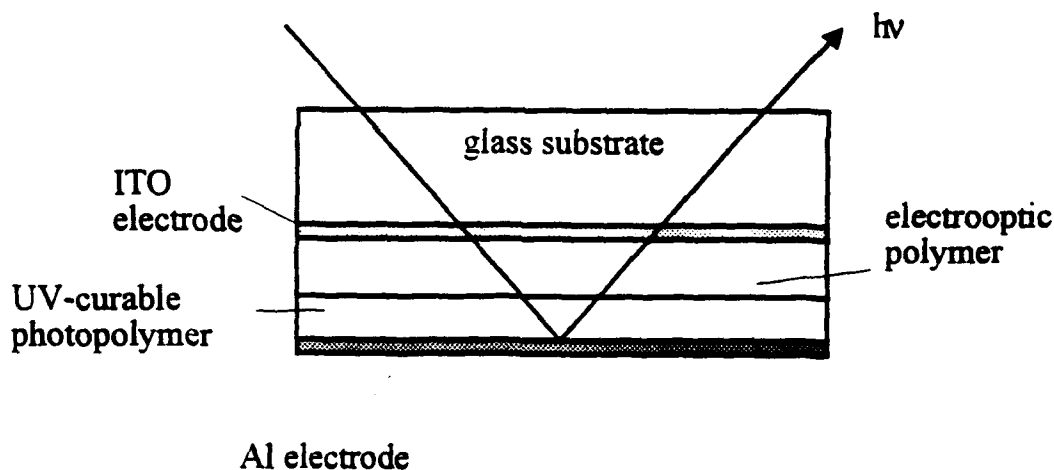
The December meeting of the Columbia Office of Science and Technology with counsel to discuss patent activity decided that a patent title search should be run immediately on thin film electronic devices (e.g., capacitors) fabricated on optical fibers, and that an invention disclosure should be filed as soon as possible on similar photodetectors. The latter was filed on 1/14/94.

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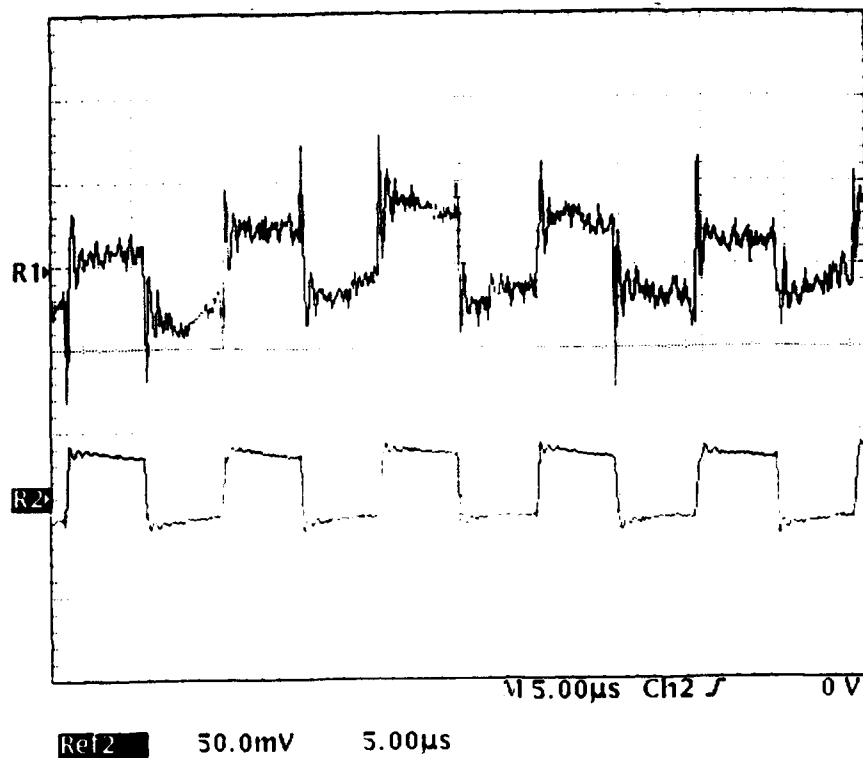
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**Fig. 1** Signal from a a-Si:H photoconductor fabricated on an optical fiber, under mechanically chopped 1 kHz light conditions (upper trace; bottom trace is reference signal). Bias was 10 V; illumination was from a HeNe laser at 633 nm at approximately 0.14 W/cm<sup>2</sup>. Transimpedance amplifier gain: 10<sup>-8</sup> A/V.



**Fig. 2** Reflection-mode electrooptic sample using PMMA:MA1 electrooptic polymer with a glass substrate. The inner electrode was transparent indium-tin-oxide (ITO, 300 nm); the photopolymer layer served to prevent electrical breakdown at higher field strengths during poling.



**Fig. 3** Traces obtained in reflection mode using 8 mW of 633 nm (cw) laser light. Detector was a single amplified photodiode (New Focus 1601). Top trace: single waveform. Bottom: waveform obtained by averaging 30 traces. Signal was a 16 V pulse applied to the polymer at 100 kHz.